Simulation of Bio-Molecular Microsystems (SIMBIOSYS)

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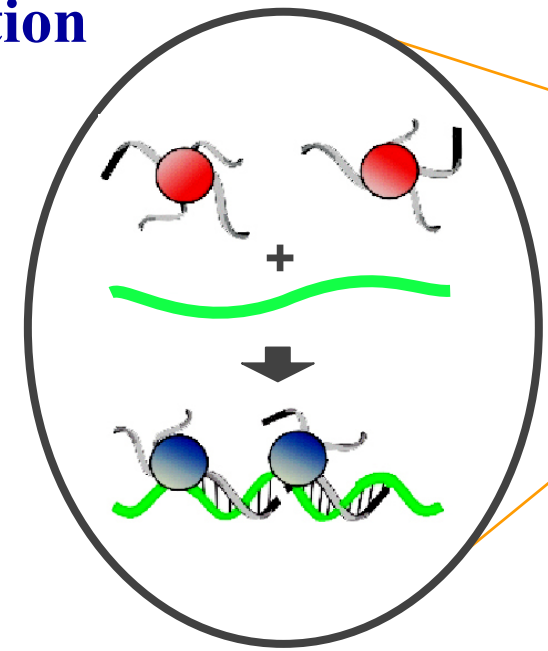
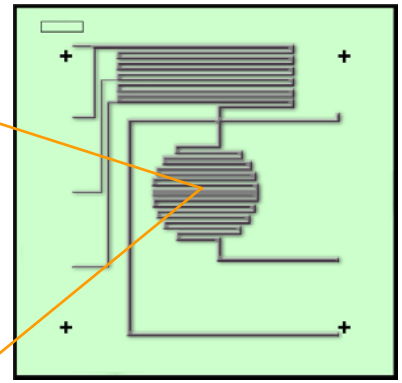
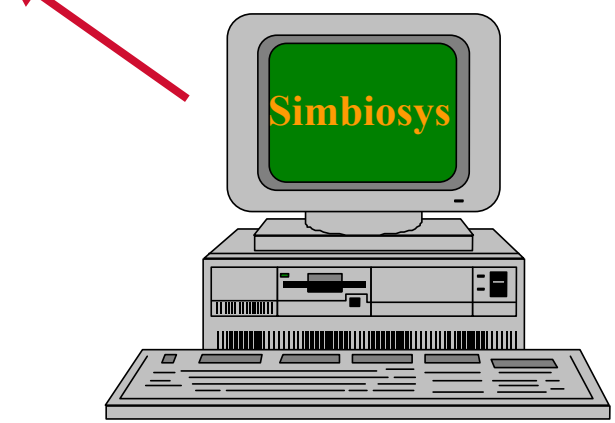
Simbiosys Program

Develop and demonstrate the capability to design chip-scale Bio-Molecular Microsystems with a high degree of multi-disciplinary integration

Interface Between Biology and Engineering :
Bio-Molecular Recognition, Signal Transduction and Fluidic Transport in Microsystems







Design of Bio-Molecular Microsystems with significantly improved speed, sensitivity, specificity and efficiency for chemical/biological processing and analysis

Simbiosys Approach

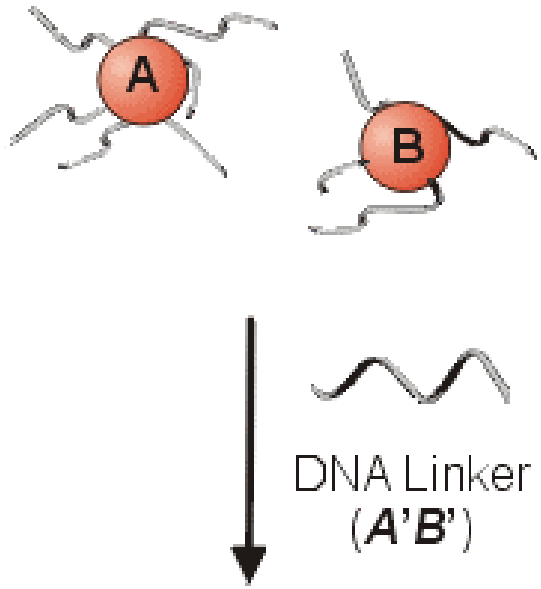
- Characterize experimentally, theoretically and computationally the elements of a Bio-Molecular Microsystem :
  - Molecular Recognition Elements
  - Signal Transduction Elements
  - Bio-Fluidic Transport Elements
- Develop phenomenological models, scaling laws and design rules for Bio-Molecular Microsystems
- Demonstrate models and design tools for the analysis and optimization of military relevant bio-microsystems in collaboration with Bio-Flips program
- Develop and transition the capability to design high performance integrated and reconfigurable Bio-Molecular Microsystems

Task 1. Molecular Recognition

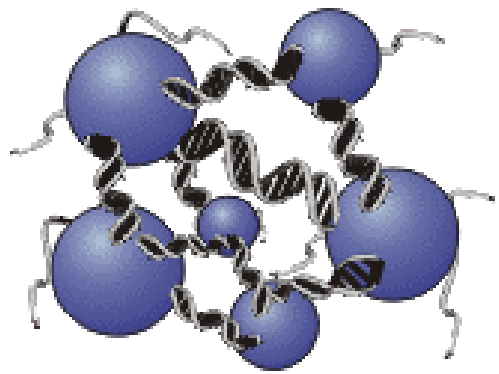
Task Goal

Develop Experiments and Computational Models to Enable the Design of Molecular Recognition Processes with (Order-of-Magnitude) :

- Increased Specificity, i.e., Significantly Reduce Probability of False Positives
- Increased Sensitivity for Extreme Low Concentration Detection
- Increased Speed for Faster Detection



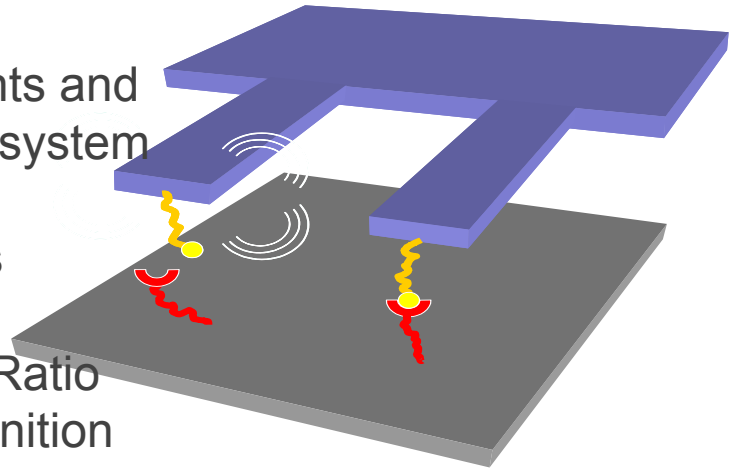
Develop Ability to Design Microsystems With Optimal Sensing Response Characteristics for Different Mission Requirements



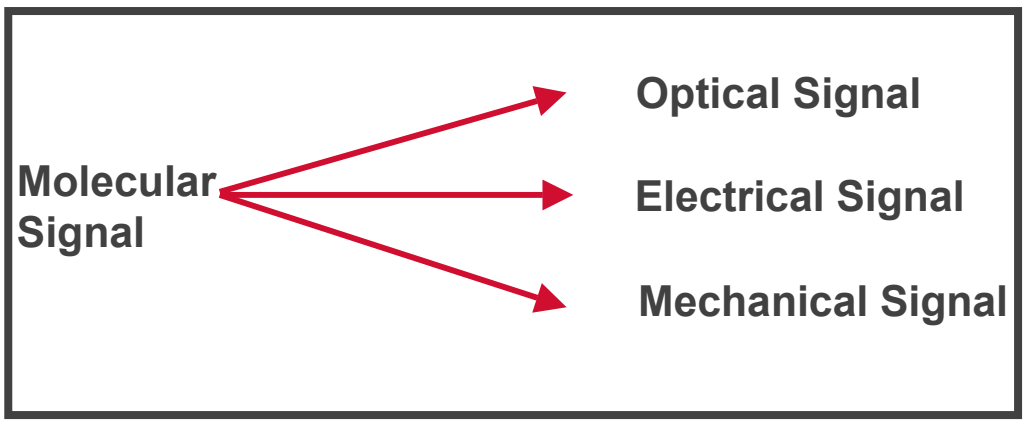
Task 2. Signal Transduction

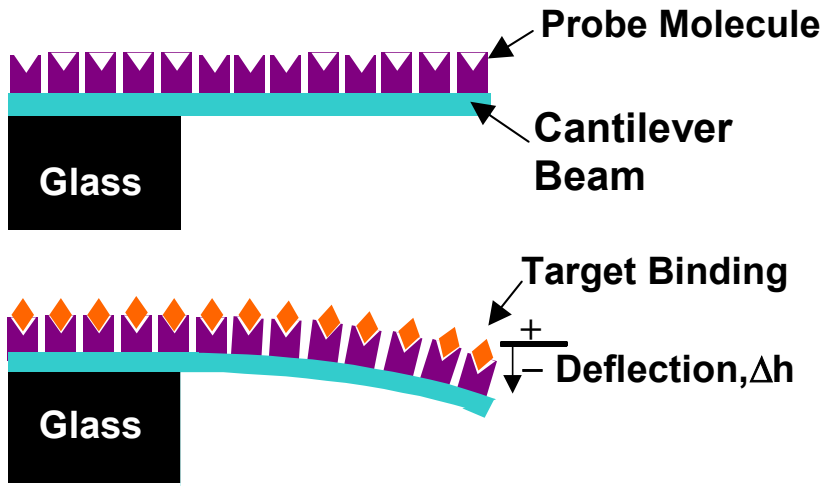
Task Goal

To Quantitatively Characterize Through Experiments and Modeling the Interface Between Biology and Microsystem EngineeringTo Transduce Molecular Signals into Measurable Electrical, Optical, Mechanical Signals



- Signal Amplification With High Signal-to-Noise Ratio
- Enable Complete On-Chip Integration of Recognition and Transduction Elements
- Enable Detection of Presence as well as Concentration of Target Molecules in Sample



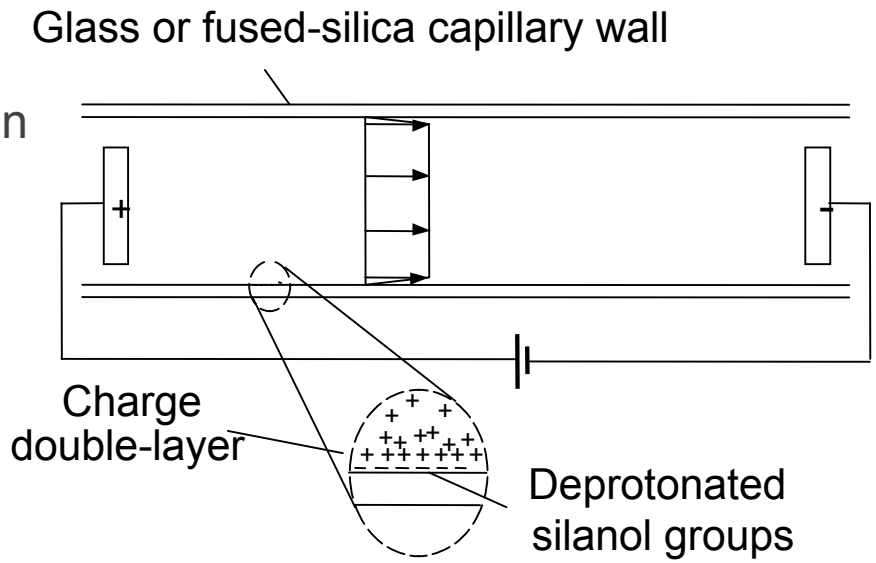


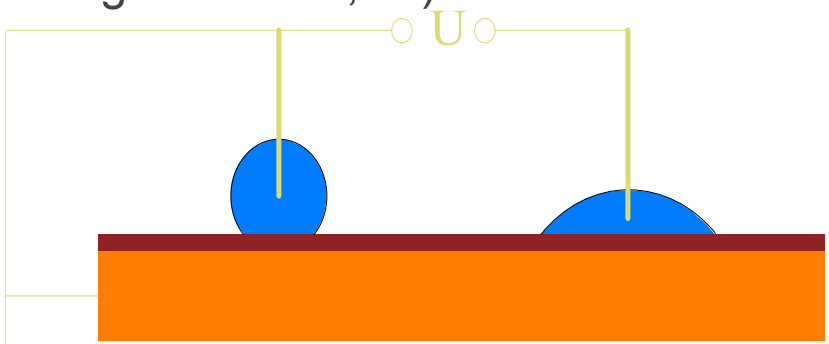
Task 3. Bio-Fluidic Transport

Task Goal

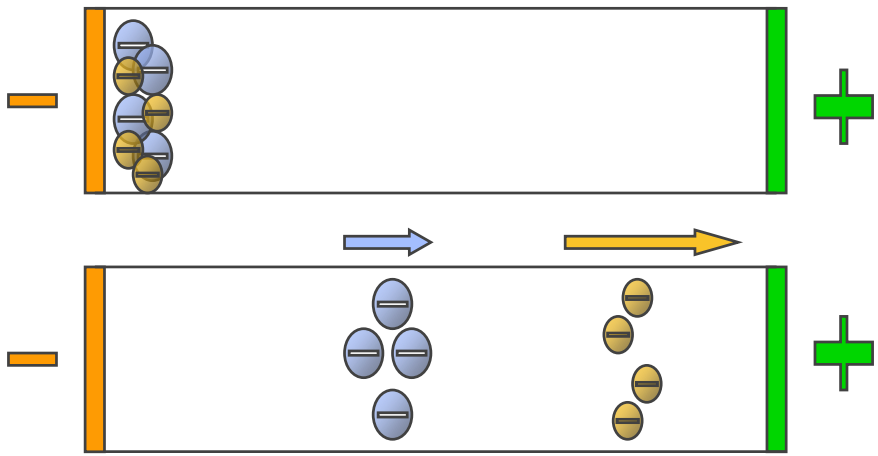
Experimental and Theoretical Characterization of Bio-Fluidic Transport Processes to :

- Optimize Pumping, Valving and Mixing Processes On-Chip
- Develop Low Power and Scalable Microfluidic Transport Protocols
- Assess Dependence of Bio-Fluid Type (DNA, Proteins, Lipids,…), Material Type (Glass, Polymer, Silicon, …) and Applied Boundary Conditions (Electric Field, Magnetic Field, …)





Surface Tension Driven Transport

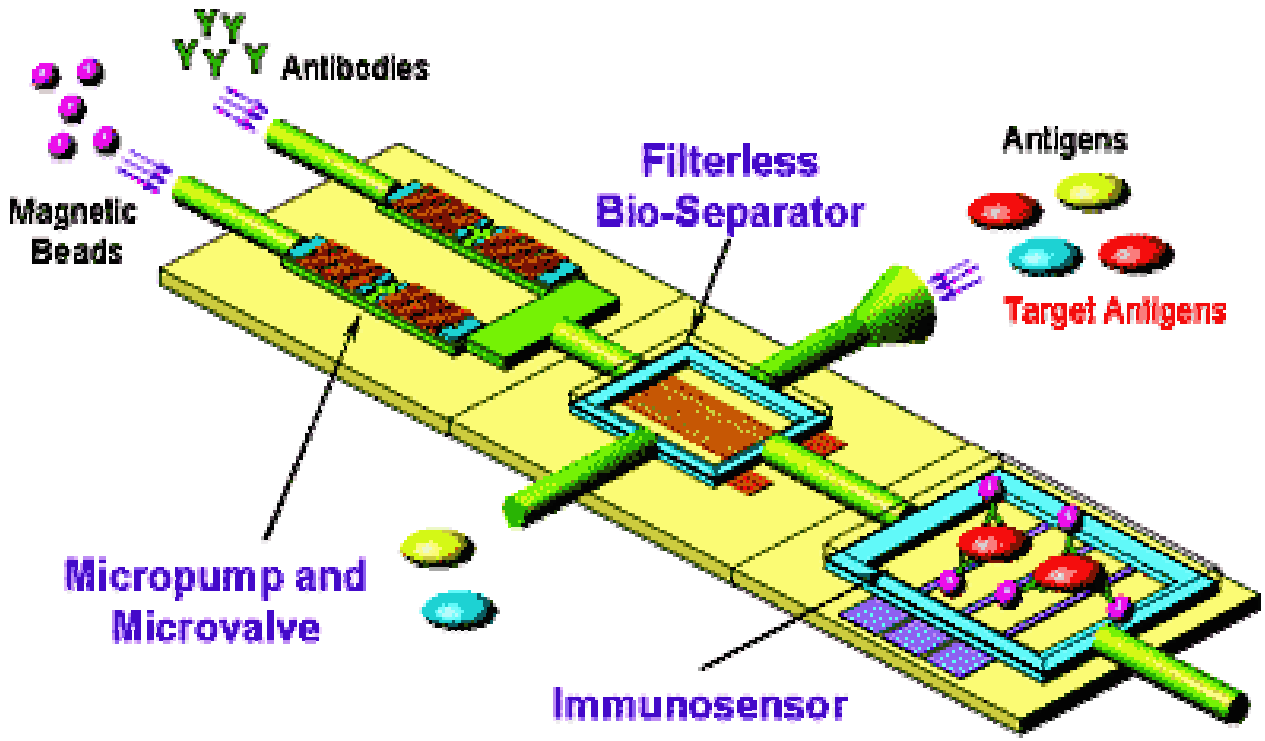


Electro-Osmosis + Phoresis

Task 4. Design Tools for Lab-on-a-Chip Systems

Task Goal

- Demonstration of Models on Bio-Microsystems : Assist Device Developers in Exploring Concepts, Optimizing Novel Designs, Anticipating and Eliminating Design Problems
- Demonstration of Validated and Verified Commercial CAD Tools to the Bio-Microsystem Community



Impact/Deliverables of Simbiosys

- It will put in place a set of experimental and theoretical models to quantify the Biology-Engineering Interface at the Molecular Scale
- It will establish fundamental scaling laws and phenomenological models for bio-micro and bio-nano systems
- It will enable orders-of-magnitude improvement in sensitivity, selectivity, SNR and efficiency of bio-molecular processes in microsystems
- It will enable analysis and optimization of bio-molecular microsystems (developed in other DARPA programs)
- It will lead to advanced modeling and CAD tools for bio-microdevice design ; Enable reduction in design cost & time of 10-100x

SIMBIOSYS will Enable Novel High Performance Bio-Molecular Microsystems For Military and Civilian Applications